from end to end of the tank, is what we think proper to denominate the *line of equivalent resistance*, because a force equivalent to the unequal pressure on the surface, if equally distributed along that line, and acting in an opposite direction, will exactly balance the aggregate pressure on the plane. It is along this line, therefore, that the transverse tie-bars should be arranged, to counteract the pressure of the water on the upright side of the cistern.

The tank being 20 feet deep, the centre of pressure is in the vertical line which bisects its side, 13⅓ feet distant from the top, and 6⅔ feet distant from the bottom; and the pressure at this depth is 833⅓ lbs. per square foot, or 5·787 lbs. per square inch; this, therefore, is to be considered as the mean force which has to be opposed or resisted by the strength of the material, and not the mean as referred to the centre of gravity of the plane.

The total pressure on the upright side of the vessel is 887500 lbs., or 396 tons, omitting the fraction; and if we suppose this pressure to be resisted by four equal cylindrical bars of malleable iron, acting transversely at equal intervals along the line of equivalent resistance, each of these bars will have to resist 99 tons of pressure, on the supposition that the vessel is full of water, and that the plane of resistance is free to revolve, as it were, on hinges at the bottom.

Now, it has been proved by experiment, that a bar of malleable iron of good quality, one inch square, when drawn in the direction of its length, will bear a strain of 30 tons before it gives way; but in order to ensure safety, and keep the strain within the elastic power of the material, it is usual in practice to allow only one-third of that force, or 10 tons to the square inch; consequently, the diameter of a round bar, to resist a strain of 99 tons under this limit, must be 3·55 inches, for we have—

$$diameter = \sqrt{\frac{99}{\cdot 7854 \times 10}} = 3{\cdot}55 \text{ inches.}$$

Hence it appears, that four bars of 3·55 inches diameter each, placed transversely at equal intervals of 14·2 feet along the line of equivalent resistance (the first and last being also 14·2 feet from the ends of the tank), will resist the whole pressure of the water on the upright side of the vessel.

This, however, supposes that the plane of resistance is free, and that no support is obtained from the connection of the sides and ends, or by any other braces or ties whatever. Now this is a condition which does not in reality exist, for a very powerful support is obtained by means of these fastenings, even to the extent of two-thirds of the whole; if, therefore, we allow two-thirds on this account, there will still remain 33 tons to be supported by each of the transverse bars, reckoning them only four in number, acting in the line of equivalent resistance. This would indeed be the best place to apply them, provided the upper part of the resisting surface was perfectly rigid, and incapable of yielding to the pressure of the water; but since this is not the case, it would be better to have a greater number of transverse bars, say twelve in all, as in the actual construction of the Liverpool tank, placing the other eight in two similar and parallel rows, nearer to the top of the vessel, or at equal intervals between the top and the line of equivalent resistance. The diameters of these bars should be diminished as they ascend, in proportion to the pressure they have to resist at the points of application, which is directly as the depth of these points below the upper surface of the water.

Dividing the 33 tons by 10, the section of the iron for three bars having the same strength conjointly as one that is capable of sustaining 33 tons, is 3·3 square inches, and the distances from the top of the vessel at which the several bars are to be fixed, are 13⅓, [illegible], and 4⅔ feet respectively; therefore, by dividing the total area of section in these proportions, we have 1·65 square inches for the section of the lower bars; 1·1 square inches for the section of the middle bars, and 0·55 of an inch for that of the top bars.

If the strain be equally distributed on the bars of these dimensions, placed exactly in the positions that we have assigned to them, and the fastenings carefully attended to, we should have no doubt of the safety of a tank of the specified dimensions thus constructed, provided all the other braces and stays are equally well adjusted; but we would certainly prefer a greater number of bars, placed at shorter intervals, and diminished in size according to their increased number. This would have the effect of shortening the leverage, and preventing the unsupported portions of the plates from bulging out to a distance beyond the cohesive power of the metal.

A similar arrangement of bars would be required for supporting the ends of the vessel, but in consequence of the great length necessary to reach from end to end, it would be convenient to fix them obliquely to some appropriate projections in the bottom, the diameters being enlarged in proportion to the diminished strength arising from the obliquity.

We have no means of comparing the above sizes of the bars with those actually employed in the construction of the vessel, for it does not appear that the sizes were stated at the inquest, and other reports that have appeared in the newspapers are in general so vague and erroneous in respect of the dimensions, that no reliance can be placed in them. It is, however, our decided opinion that the accident arose more especially from bad arrangement, and imperfections in the fastenings and boltings of the ties, than from any deficiency in the actual strength; and we are led to this conclusion by attentively considering the evidence of Mr. Grantham, where he states, that the rupture occurred at about 28 feet from the south end of the vessel. Now this was immediately contiguous to the second vertical tier of bars, where we would have expected considerable stiffness to prevail; but the circumstance of the rupture occurring at that point, induces us to believe, that the bars slackened at that tier, thereby doubling the leverage on the plates between the first and third tiers, and admitting the sides to bulge out beyond the limits of the cohesive power of the material.

There can be no doubt that the cast-iron plates were of sufficient strength to resist all the pressure to which they were likely to be subjected, provided they had been properly tied to break the immense leverage of 71 feet; we cannot say that we much approve of the variation of thickness in the panelling, but even admitting this to a small extent, there was still sufficient strength in the plates to resist the pressure with proper stays.

We reason on this point from the comparison of a cylindrical vessel of equal sectional area, for in this case, an inch of thickness in the metal, would be safe under a pressure of 101 pounds to the square inch, and certainly a rectangular vessel of similar thickness at the point of equivalent strain, would be safe under a pressure of only 5·787 pounds.

The theorem for calculating the amount of pressure, or lateral strain on one inch of a cylindrical vessel, is

*pressure = thickness × cohesion ÷ radius ÷ thickness.**

And applying this to the case before us, we get—

$$radius = \frac{1}{2}\sqrt{\frac{24.5 \times 20}{\cdot 7854}} = 12{\cdot}49 \text{ feet;}$$

and taking the thickness at one inch, it is—

$$pressure = \frac{1 \times 15300}{149{\cdot}88 + 1} = 101{\cdot}3 \text{ lbs. } \textit{per square inch of cylindrical surface.}$$

We now conclude our remarks by observing, that far greater safety would have been ensured by dividing the vessel transversely into several compartments, by means of plates similar to those in the sides and ends, this would have rendered the whole structure much more rigid, and given firmer bindings to the sides; the supply pipe could easily have been so arranged as to fill all the compartments simultaneously, or they might have been left to fill one from another by means of hydrostatic pressure, the water being urged through orifices left for the purpose.

We do not pretend to say, that the remarks which we have thrown out are strictly in accordance with the practice of the engineers, nor do we warrant the correctness of the conclusions which we have drawn, they are such as occurred to us from the information that we possessed, and they may be useful in guiding practical men in similar cases. T.

* This rule may be seen in Turnbull's "Theory of the Hydro-mechanical Press," published by Taylor in 1831. Or the "Mechanics of Fluids for Practical Men," published under the name of Alexander Jamieson, LL.D.; but which, in reality, is the production of the individual just named.

INSTITUTE OF BRITISH ARCHITECTS.

An ordinary general meeting was held on Monday, the 12th instant; Mr. Kendall, vice-president, in the chair. The following letter, dated Athens, and addressed to Professor Donaldson, was read:—

"My dear Sir,—When I saw you last in England, I gave you the promise of a letter from Athens, and I attempt now to fulfil it.

The Acropolis, with its glorious remains of architecture and sculpture, is the only interesting theme here; and, to architects, the Temple of Art, where all must worship.

The Archæological Society here have done several interesting works since I first visited Greece. The rubbish which encumbered the portico of the Erectheium in the shape of a powder magazine, has been cleared away, and that beautiful doorway, which I recollect as given in your work on "Doorways," is exposed to view. It is much mutilated, I am sorry to say; but that which is left perfect, shews the same unrivalled delicacy of workmanship which is visible throughout the whole of the details of the Temple.

On the south-side of the Parthenon, the society have been clearing away the fallen fragments, and in doing so, have shewn the foundation wall to the depth of about ten feet. In the course of this work, two pieces of sculpture, forming part of the sacred procession, which was round the cella, were turned up; a slight sketch of them, which I lithographed, I have inclosed to you. A considerable part of the wall of the cella has been rebuilt, and most of the fragments in the interior of the Temple have been removed. The interior now offers greater facilities for speculative, or rather, I should say, conclusive imaginings on its decoration. There are evident traces of Doric columns, with marks of their flutings, &c., visible on the floor of the interior. The diameter of these columns has been 3 feet 7½ inches; and on both sides it is clear there have been nine, counting from the east end, at which there is the remnant of a pilaster, the breadth of the diameter of the columns. The other parts of the interior cannot be determined in the same decided traceable way, therefore I will refrain from giving you any conjectures which may be erroneous.

The Temple of Victory has also had the attention of the society, and it is now restored, as far as possible, with the sculptured frieze, &c.

At present, the labours of the society are directed to clearing away the rubbish on the north side of the Propylæa.

In different parts of the Acropolis several remains of walls, &c., have been discovered, probably of earlier temples. A correct survey of the Acropolis, I have often thought, would be very interesting to architects and archæologists in England, with all their particulars of walls and spots marked on it; and as I am here, I should be very glad to undertake a work of that kind, if there were any likelihood of remuneration.—I am, yours faithfully,

GEORGE KNOWLES."

Mr. Britton then read a very interesting paper "On the design, construction, and architectural characteristics of the collegiate chapel at Roslyn, Scotland;" and illustrated it by a number of excellent drawings. Roslyn is a few miles south of Edinburgh; the celebrated chapel was founded, it is always asserted, by William de St. Clair, in the fifteenth century. A manuscript in Hay's collections, quoted by Mr. Britton, says:—

"He builded the church walls of Rosline, having rounds with fair chambers and galleries thereon. He builded also the furework that looks to the north-east. He builded the bridge under the castle, and sundrie office houses. In the south-east side thereof, over against the chapell wall, he made plaine the rock on which the castle is builded, for the more strength thereof, and he planted a very fair orchard. But his age creeping on him made him consider how he had spent his time past, and how to spend that which was to come. Therefore, to the end he might not seem altogether unthankfull to God, for the beneficies receaved from him, it came in his minde to build a house for God's service of most curious work, the which, that it might be done with greater glory and splendor, he caused artificers to be brought from other regions and furraigne kingdomes, and caused

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